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survey especially requires that economic work should be done, and as the primary function of the survey is the performance of such work, it is evident that this class of investigation has been carried on strictly in obedience to the law, and in fulfilment of its purpose.

The annual output of the mines of the United States aggregates in value about \$425,000,000; and, while the economic results of the survey have largely been devoted to this industry, the needs of the agricultural community have not been forgotten. At present investigations are going on of the flood-plain valleys of the great rivers, like that of the Mississippi, for the purpose of determining the conditions under which they can be redeemed; and, on the other hand, of the great arid regions, to determine by what means they may be more economically fertilized by irrigation; and, again, of the coast marshes and interior swamps, to learn the possibility of their utilization by drainage. In the prosecution of its topographical work, the survey is constructing a map of the forests of the country; and in its study of the structural geology it is revealing the conditions under which artesian wells may be discovered, and prognosticating the areas where such wells may be constructed. In the study of the interior hydrography of the country, the survey is developing the conditions under which our towns may obtain a supply of healthful water; and, in this connection, the calls upon the survey for information are many and rapidly multiplying. It is hardly necessary to add, that, in the construction of a topographic map of the United States, the people are supplied with a knowledge of the natural routes for the highways of commerce. It will thus be seen that the work of the survey has practical relations with all the industries of the people, and that it is pre-eminently designed to promote their welfare.

THE RAILWAY TO CENTRAL ASIA.

UNDER the direction of General Annenkoff, the Transcaspian railway has made remarkable progress. At the beginning of the present year it extended from Mikhailovsk, on the bay of the same name, to Ghiaurs, a small station some miles beyond Askabad. From thence to Merv the road-bed is finished, and the stations and bridges are constructing. It is expected that trains will run to Merv this spring, and that by midsummer the road will be completed to the Amu Daria at Charjui, a total distance of one thousand and forty-one kilometres. The harbor at Mikhailovsk is very shallow, and the deep water at Krasnovodsk is too distant; but another spot has been found, twenty-four kilometres from

Mikhailovsk, where, by a moderate amount of dredging, the largest vessels of the Caspian can come up to a jetty now building. For the other end of the line, to connect with the railway, steamers of a special type are being constructed, suited to cope with the swift and shallow waters of the Amu Daria. The difficulty presented by drifting sands in the desert is to be met by introducing plants, already tested for such purposes in the arid regions of Algeria; and at the principal stations large quantities of them are already being set out in propagating-houses.

This enterprise is a military road, built and designed by officers of the war ministry, assisted by soldiers, Tartars from the Caucasus, and Turkomans and other inhabitants of the region. The chief difficulty has not been the sands of the desert, but the want of water; the existing wells being far apart, brackish, and hardly sufficient for the ordinary purposes of the caravans. However, it has been determined by experiment, that, at a certain depth in the soil, water exists in sufficient quantity, and increases at greater depths. Artesian wells will therefore be dug, the machinery for which is already on the ground. The worst part of the line determined upon is the desert which extends some two hundred kilometres eastward from the Merv oasis. This, though arid and sandy, produces a growth, sometimes almost a wood, of the 'saxaul' (*Haloxylon ammodendron*) and other nearly related shrubs, which only disappear at a distance of some forty kilometres from the Amu Daria.

After passing the lesser desert near Mikhailovsk, and reaching the station at Kizil Arvat, the railway takes a direction parallel to the Kopet range, which coincides with the borders of Persia. It crosses the Akhal oasis, and passes under the walls of Geok Tepe a few yards from the spot where the assault was made by which the fortress was carried. The most important station is Askabad, a flourishing town only three years old, but already enjoying an important commerce with North Khorassan. Farther on, the line passes the Persian village of Lutfabad at a distance of two kilometres, and enters the Attek oasis, now beginning to revive under the security afforded by Russian rule. Duchak, at 391 kilometres from Kizil Arvat, is the most southern point of the line, from which diverge the routes to Séraks, Heshed, and Herat. Here the road turns toward Merv, and enters the desert in a north-westerly direction. There are no brooks or springs, but from the mountains to the south-east come two rivers of importance,—the Tajand or Hari-Rud, and the Murghab. The former is dry in winter, but in summer has twice the volume

of the Murghab. To the north-west both rivers are lost in the sands of the desert. The Hari-Rud is crossed by a bridge ninety-seven yards long. From this point it was formerly a distance of ninety kilometres to the nearest fresh water, but this has been diminished to forty-eight kilometres by a canal constructed by Colonel Alikhanoff during the past season. This diverts part of the water of the Murghab, but it was found impracticable to extend it further. The latter river, unlike the Hari-Rud, does not dry up, but carries in winter seventy-five cubic metres per second as against three hundred in summer. It contains about two per cent of earthy matter, amounting, for the annual epoch of floods, to about fifty million cubic metres of mud, which is spread by the innumerable irrigating canals over the surface of the Merv oasis. The destruction in 1784, of the great dike of Sultan Bend, much diminished the irrigated and fertile area. The Russian government has reserved sixty thousand rubles to rebuild this dike, and it is expected that nearly four hundred thousand acres will be reclaimed by this work, and, in time, nearly four times as much more. This land, when irrigated, is of extreme fertility, wheat producing a crop of one hundred bushels for every bushel sown. Merv is growing rapidly: town lots of a certain size are given away, on condition that the receiver builds upon them at once. The streets are wide, with broad footwalks, planted with trees, and bordered with small canals. The oasis is confidently expected to develop largely in the near future.

PHOTOGRAPHIC STUDY OF STELLAR SPECTRA.

THE study of stellar spectra by means of photography was one of the most important investigations undertaken by the late Prof. Henry Draper. He was actively engaged in this research during the last years of his life. His plans included an extensive investigation, one object of which was to catalogue and classify the stars by their spectra. Mrs. Draper has made provision, at the observatory of Harvard college, for continuing these researches as a memorial to her husband. The results already obtained, with the aid of an appropriation from the Bache fund, permit the form of the new investigation to be definitely stated. The part of the sky to be surveyed is that extending from the north pole to the parallel of thirty degrees south declination. Each photograph will be exposed for about one hour, and will include a region ten degrees square. The telescope employed has an aperture of twenty centimetres (eight inches), and a focal length of a hundred

and seventeen centimetres (forty-four inches). The object-glass is covered by a prism, and the resulting spectrum of each star in the region photographed has a length of about one centimetre, which enables the character of the spectra of stars from the fifth to the eighth magnitude to be determined. A modification of the apparatus is employed for the brighter stars.

Meanwhile, experiments are in progress with the fifteen-inch equatorial, with the object of representing the spectra of some typical stars upon a large scale. The spectra so far obtained are about six centimetres in length, and exhibit much well-defined detail. Additional experiments will be tried with a spectroscope provided with a slit, as well as with the simple prism hitherto employed, in order to secure the best possible definition. The present results encourage the expectation that the movements of stars in the line of sight may be better determined by the photographic method than by direct observations.

To keep the astronomical public informed of the progress made in this work, specimens of the photographs obtained will be gratuitously distributed from time to time. The first of these distributions will probably be made in a few weeks. Owing to the expense of providing a large number of copies, it is desirable to limit the distribution, so far as possible, to those who are interested in this class of work. It is also desired, however, to send the specimens to all who will find them of value from the scientific point of view. Requests should be sent to the Harvard college observatory by any one desirous of receiving the specimens. EDWARD C. PICKERING.

THE HUDSON BAY ROUTE TO EUROPE.

LAST year there appeared in *Science* (vol. v. No. 110) an account of the Hudson Bay expedition of 1884, accompanied by a track-chart showing the route followed. Lieutenant Gordon's official report of his last summer's trip to the bay, to relieve the observers at the stations established in the strait in 1884, is included in the annual report of the Canadian department of marine, lately submitted to the Dominion parliament. It is in narrative form, and contains little new information, the results of the observations conducted at the several stations being reserved for publication as a separate report so soon as they shall have been reduced to proper form.

Lieutenant Gordon, after promising details of the observations at an early date, concludes his report with the following remarks on the prospects of navigating the strait: "The reports go to show that the ice set fast in the western end of